Analysis of grain size evolution using an extended two-size approximation model

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In this presentation, we construct a dust evolution model that extends the two-size approximation [1] to a two-phase medium consisting of hot and cold gas. We then discuss the resulting evolution of dust grain sizes.

Dust is thought to influence galaxy evolution by promoting star formation through processes such as molecule formation on grain surfaces, radiative cooling, and UV shielding. It is also believed to affect the spectral energy distribution of galaxies. Since these effects depend on dust size and composition, developing detailed dust evolution models is crucial not only for theoretical studies but also for interpreting observations. Although a full calculation of the size distribution is ideal for modeling dust evolution, it is computationally expensive. However, the essential characteristics of dust evolution can still be captured by using a simplified two-size approximation model, separating grains into large and small populations. Therefore, we adopt the two-size approximation as a first-order approach in our calculations.This method based on Hirashita(2015) [1].

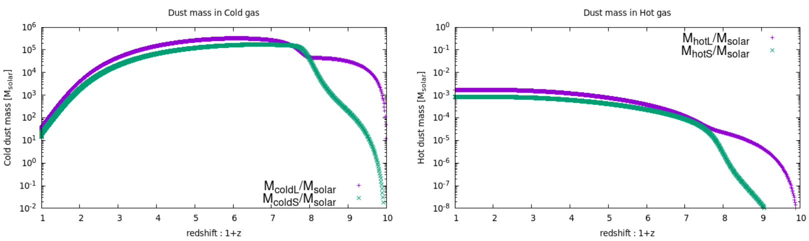

Figure 1: Dust mass evolution in cold gas (left) and hot gas (right) as a function of redshift.The purple and green solid lines correspond to large grains and small grains, respectively.

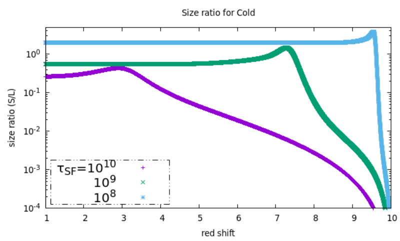

Figure 2: Variation in the small-to-large dust mass ratio for different star formation timescales.

The results of our calculations are shown in Figures 1, and 2. Figure 1 presents the evolution of dust mass in cold gas as a function of redshift. Initially, large grains dominate the dust population, but around redshift $z \sim 8$, the masses of small and large grains become comparable. Eventually, the dust masses of both size populations reach similar values.

Figure 2 shows the evolution of the small-to-large dust mass ratio as a function of redshift for different star formation timescales. The fiducial model corresponds to a star formation timescale of $\tau_{\mathrm{SF}} = 5 \times 10^9$ [year]. In the case of a shorter timescale ($\tau_{\mathrm{SF}} = 5 \times 10^8$ [year]), the ratio of small dust grains was found to increase sharply in the early stages, and small grains remained dominant thereafter. This behavior is expected to occur in environments with intense starburst activity, such as in early galaxies, and may have a significant impact on our understanding of galaxy evolution.

References

[1] Hiroyuki Hirashita, MNRAS, **447**, 2937-2950 (2015)